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ABSTRACT

The Learning in Science Project established that children from a young age construct out of their everyday experiences views which they use to explain their world and that these views are remarkably resistant to replacement by scientifically more useful views. Although science lessons tend to be based upon activities which are designed by teachers and textbook writers to establish specific scientific viewpoints, experience with these activities does not have the intended influence for many children. Their views, if changed at all, are not changed in the expected way; they remain unaware or unimpressed by the scientific viewpoint. Provided in this paper are six reports from teachers on strategies (developed or used in response to particular problems identified by the Learning in Science Project which increase the likelihood that a science learning experience does indeed provide the particular intellectual challenge that is intended. Each report includes: problem area; teacher's thinking related to problem and solution offered, instructional strategy(ies); impact of the strategy(ies) on students; and editor's comment linking the report to other aspects of the Science Activities Action-Research Group. Also included are three checklists: for planning science activities, for evaluating a science activity, and for student evaluation of a science activity. (JN)

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LEARNING IN SCIENCE PROJECT

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SCIENCE ACTIVITIES

Specific problems – some solutions

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WORKING PAPER No. 48

This paper is part of a set of four papers that deal with the work of the Science Activities Action Research Group. The set is:

No.46	Science Activities:	Report on the Science Activities Action Research Group
No.47	Science Activities:	The Problem.
No.48	Science Activities:	Specific Problems - some solutions
No.49	Science Activities:	Wider Issues - Some considerations

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No.	Visit to a Classroom No.4

SCIENCE ACTIVITIES: SPECIFIC PROBLEMS - SOME SOLUTIONS

Ross Tasker and John Lambert (Editors)

November 1981

INTRODUCTION

The work on Children's Science by the Learning in Science Project established that children, from an early age, develop views of events and phenomena and meanings for words which they use to describe the world as they see it. Many of these; while not necessarily those of the scientist, are sensible and useful in terms of their experiences and, as a consequence, strongly held. Children bring these views and meanings to the science classroom where, unless challenged by an appropriate learning experience, they are frequently retained. This paper is concerned with strategies which increase the likelihood that a science learning experience does indeed provide the particular intellectual challenge that is intended.[1]

The paper is a series of reports from teachers on ways which they have developed or used in response to particular problems identified by The Learning in Science Project. These problems are summarized in Table I.

1. Clearly with certain activities it may be the teacher's intention that an explicit purpose is not desirable.

Problems that occur in science lessons

	Some possible mismatches between teacher and pupil preceptions. It would be extremely rare for all these to occur in any one lesson		Some consequences of the mismatch (if it does occur).
Relating to setting the scene of the lesson	**Teacher's Viewpoint**	**Pupil's Viewpoint**	
a. Scientific context of the lesson/activity	The lesson/activity is seen as part of a related series of experiences	The lesson/activity is seen as an isolated event.	Pupils do not consider the lesson/activity against important prior experiences.
b. Scientific purpose of the lesson/activity	The scientific purpose of the lesson/activity is specific and obvious.	The purpose of the lesson/activity is not obvious.	Pupils guess at and invent what seems to them to be a reasonable purpose.
c. Scientific design of the investigatory activity	The activity has certain critical scientific features which enable particular ideas to be tested.	The critical scientific features of the activity are not recognised or understood.	Pupils are unaware of which aspects of the activity need particular attention and why.
Relating to pupils			
a. Doing the activity	What the pupils are to do is obvious and requires skills the pupils possess.	What to do is not understood and the skills needed are not available.	Pupils do things which they think appropriate to reach the end of the activity.
b. Getting results	Pupils know what to look for and will recognise the result of the activity.	What to look for and how important a result is, is not clear.	Pupils focus on, and observe, unexpected aspects of the activity. They are preoccupied with "What is supposed to happen?"
c. Thinking about what was done and what happened	Pupils will consider critically their actions and findings.	There is no awareness that actions and findings should be critically examined.	Pupils see the activity as 'getting the right answer' or guessing what the teacher wanted from the activity.
Relating to outcomes achieved			
a. Evaluation of the experience	Pupils will consider the experience against the ideas and perceptions of scientists' science.	The experience if considered against ideas and perceptions of childrens' science.	Pupils have difficulty relating what they did and saw happening to their thinking.
b. Significance of the experience	There are pre-determined outcomes which are significant for achieving the teachers aim.	The significant outcomes are not detected or detectable because they do not relate to the personal view held.	Pupils develop negative attitudes to school science as being not relevant.

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Table 1

REPORTS

The reports which follow all have the same format i.e.

(1) The problem(s) for which a solution was being sought is stated (and linked to Table 1).
(2) The teacher's thinking relating to the problem and the solution is provided.
(3) The teaching strategy(ies) developed and/or used is described.
(4) The impact on pupils of the teaching strategy is described.
(5) An editor's comment is provided to link the particular study to other aspects of the Action Research Groups work.

REPORT ONE : ACHIEVING A FRAMEWORK

Problems

* Pupils do not consider the activity against important prior experiences (1a in Table I)
* Pupils guess at and invent what seems to them to be a reasonable purpose for the activity (1b in Table I)
* Pupils are unaware of which aspects of the activity need particular attention and why (1c in Table I)

Teacher Thinking

Before undertaking an activity pupils should be given time to place the actions and materials of the activity against the views they bring to the lesson. As the teacher there may be views which I consider important to be seen in relation to the activity. By creating situations in which pupils get to discuss their thinking with other pupils and/or me, pupil's views become apparent and can be used to explore the nature and purpose of the activity.

Note: I use this approach with all my Form 3-5 classes. The strategy works equally well in any classroom setting and with any ability group.

Teaching strategy one: Co-operative and Independent Reading

a. For dependent readers

I use a method of co-operative reading with such a group, usually of 5-10 pupils. We form a semi-circle at one end of the room and discuss as we read the introduction and instructions for the activity. The discussion is directed by questions which I structure and introduce. These questions are related to important words, ideas, actions and critical features of the activity.

One way that I direct such a discussion is set out below.
We consider ...

The Introduction	:	Read and predict the remainder of the Section.
The Visual Material	:	What are the pictures/diagrams showing?
The Written Material	:	Sections are read orally by teacher, others silently by pupils. Frequent pauses for comment, prediction, conjecture.
The Instructions:	:	An oral description from pupils of the expected sequence of actions.
Review	:	What are the pupil predictions and views now?

b. For independent readers

Pupils discuss a number of teacher framed questions related to the activity. These are presented either on the blackboard or on cards. The questions are designed to raise the same issues as those introduced orally when talking with the dependent reader group. A leader is appointed and this pupil directs the discussion.

I have found that pupils respond positively to this approach.

Note: This strategy I use in conjunction with that described for dependent readers. Together they provide a suitable introduction to an activity for all pupils in my class.

Impact of the strategies

a. I find this approach gives students the confidence required to deal with ideas and instructions which are written in a scientific language. Individuals within the group can help each other with the ideas contained in the instructions and, as a consequence, any actions are moderated by group interaction.

b. I find that with this approach the confidence and independence of readers is markedly increased when confronted with a science activity. Key aspects of the activity appear to be appreciated and my purpose for the activity is clearly seen. Furthermore I feel that pupils gain an overview of the activity which in the absence of such directed discussion is seldom apparent.

Pupil: "This (strategy) helps because one person has an idea that may be quite different to yours".

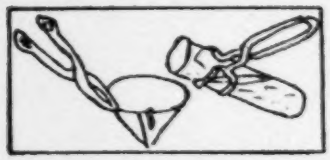
Teaching strategy two: Group Sequencing

Before the lesson I cut up a worksheet, photocopies of a textbook page, diagrams or whatever material the class is using. These sections are scrambled and placed on an envelope. Groups in the class then reassemble the material into a sensible order discussing reasons and finally answering teacher directed questions before carrying out the activity. Time spent by pupils is generally no more than 10 minutes.

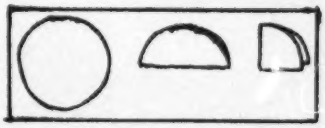
Note: I find that by using this approach once or twice early in a term the pupils develop the habit and skill of considering the implications in an activity's description and instructions.

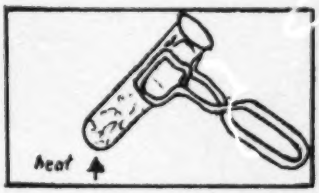
Example 1: This example is taken from an activity where pupils make 2 types of sulphur crystals. Pupils are required to associate the appropriate instruction with each diagram then work out the sequence of actions required.

Sulphur crystals can have two quite different shapes, depending on how they are prepared. To get the first type:



Organize the instructions below into this space so that each instruction is linked to its diagram. Then work out the order in which you are to do the activity.





You should be able to see the crystals.

Draw them to show what shape they are. (YOU may need a magnifying glass.)

These are crystals of monoclinic sulphur.

Instructions to fit in above.

When a crust has formed, take off the paper clip and open up the paper.

But instead, fix it with a paper clip and hold it with tongs.

Fold a filter paper as though you were going to put it in a funnel.

Pour melted sulphur into the filter paper.

Half fill a test-tube with small pieces of roll sulphur. Warm GENTLY in a fume cupboard.

Example 2: Unscramble these paragraphs

the young animal and the cord which joins it to the foetal membranes and the placenta either breaks, or it is bitten off. Some time later the membranes and the placenta which sheltered and fed the foetus are also pushed out of the uterus. These now useless parts are called the afterbirth.

Once outside its mother's body it quickly draws air into its lungs and starts gathering its own oxygen instead of getting it from its mother. At birth the blood stops flowing out to the membranes and through the placenta. Most of the blood passes into

The young mammal is not able to care for itself yet. For a time it feeds on its mother's milk, and only gradually changes to adult food.

Some young mammals like foals, leverets and young guinea pigs are fully active soon after birth, but others, like human babies, rabbits and mice, are almost helpless and often blind at birth.

The birth process

When the young animal has developed to the stage where it can live outside its mother, it is born. The mother's body has also been preparing for the birth. The muscles in the uterus begin to contract, fairly gently at first but with growing strength. Soon the membranes burst and the fluid leaks out. The muscular contractions become stronger still and the young animal is forced out of the uterus, through the vagina and out into the world.

Impact of the strategy

I find that the strategy forces pupils to consider and discuss what an activity is about, what they have to do and what it all meant before they get actively in doing the activity. Fewer pupils are off task and most are able to discuss with me the implications of their action.

Pupils: P1 "I read through it (each paragraph in example 2) and read through it a couple of times to get them in order, and everything and when you get them in order you just read through it to make sure you know what you are doing".

P2 "You read it, you've got to understand it (example 1) before you find out when the activities go".

P3 "Made you think more, you have to read it to put it into place".

Editor's comment

Many textbooks tend not to provide clear opportunities for pupils to really understand the nature of an experiment and what it is all about. Time spent on this by pupils and the teacher would appear to be time well spent. A number of possible strategies might be used to ensure an overview of the activity is gained by all pupils before they start so that they can answer the question "What am I doing and why am I doing it?" from a sound scientific perspective. The above gives two clear examples of things that might be tried to solve this problem in your classroom.

REPORT TWO : GETTING THEM 'ON TRACK'

Problems

* Pupils guess at and/or invent what seems to them to be a reasonable purpose (1b in Table 1)

* Pupils do things which they think appropriate to reach the end of the activity (2a in Table 1)

Teacher thinking

My initial reaction to the problems outlined in Table 1 was to think of how difficult it must be for pupils with their limited experience of scientist's science to see in an activity the same opportunities for learning as we teachers do. From our perspective most activities are simple and it is clear cut as to what is involved and what particular

findings mean. Too often we fall into the trap of forgetting this gap between our perspective and our pupils. My response has been to try and structure my planning of activities in a way which,

a. keeps the pupils' perspective in the forefront of my thinking.

b. forces me to consider very carefully what I am asking my pupils to do and match that with my knowledge of their views, skills and attitudes.

c. is not too time consuming and will provide a record of an activity for future reference.

Teaching strategy

Develop and use an Index of activity plans.

I now condense my planning of an activity onto index cards (I find the 300 x 200mm size ideal) which require me to pay attention to particular aspects of the activity. Some of these aspects are bread and butter items, but others link strongly to problems in Table 1. The size of the card does not allow for much elaboration but the cards are very easily stored and referenced.

CARD NO 1			Side 1
Activity Title:.....			
Reference:.....			
Type: Demo	Group	If group, no of groups	
Equipment for Each Group:.....			
.....			
.....			
INSTRUCTIONS:-			
SHEET	BOARD	OHP	SPOKEN	BOOK
LENGTH OF TIME	1/2 P	1P	LONGER	SPECIFY

Side 2
ACTIVITY TITLE:.....
OBJECTIVES: (a) Knowledge (b) Skills (c) Attitude
PREKNOWLEDGE (Can this class do what you ask in the instructions)
WORD LIST (Words to add to list in your notebooks)
TYPE OF RECORD
EVALUATION (How good or successful was this? Modification?)

Note: Side 1 of the card which deals with mainly resource requirements for the activity, is proving to be an easy way of indicating what I need to our resource person.

Impact on pupils

This is very hard to gauge. However, I see potential for evaluation in the checklist 'A checklist for pupil evaluation of a Science Activity' (see REPORT SIX, p. ..) and will use this with my classes to get feedback on the impact on pupils of my planning.

Editor's comment

The use of a planning guide is likely to assist teachers in their attempts to avoid overlooking key aspects of an activity. Moreover, when the guide incorporates an evaluation of the class's interaction

with the activity (an evaluation which is recorded along with the planning notes for the activity on a card which can be readily stored for future reference), there would appear to be real benefits for both pupils and the teacher. The checklist referred to, together with the other checklists set out in Report Six, offer a more detailed way of considering these (and other) problems. The use of the Index of activity plans in conjunction with the checklists would seem a very powerful planning approach.

REPORT THREE : MAKING INSTRUCTIONS MEANINGFUL

Problems

* Pupils guess at and invent what seems to them to be a reasonable purpose for the activity (1b in Table 1)
* Pupils do things which they think appropriate to reach the end of the activity (2a in Table 1)

Teacher Thinking

What is to be done by pupils in a particular activity is a result of either:

1. The teacher's pre-work discussion and his verbal instructions (whether explicit or implied),
2. Written directions for the work,
3. A combination of the above.

The teacher usually assumes as a result of either 1. or 2. above, that the actual pupil actions are now straight-forward and obvious. Unfortunately I have found this to be often far from the case. As is indicated in the Table (1b) unless the aim of the whole activity is clearly understood by all the pupils, even the simplest of instructions may be misinterpreted, or just not thought about enough in relation to the whole experiment and consequently performed in a manner which is partially correct or sometimes in quite the wrong direction. For example, the instruction "Fill a test-tube with water" (which formed

part of an activity involving the collection of a gas by downward displacement) was not appreciated by many pupils in a 3rd form mixed ability class. This simple instruction meant 'put some water in a test-tube' to a significant number of trial pupils. The effect of this interpretation of the instruction was to establish an air bubble in the top of the test-tube when it was inverted and to reduce the likelihood of expected findings being achieved.

Teaching strategy one: Give emphasis to important instructional words, so that there can be no doubt as to meaning.

Taking the example used in the introduction above this could be

"Completely fill a test-tube with water".

This is an extravagance and an incorrect use of the English language, but the alternative is to teach all the words you want to use before an activity.

Teaching strategy two: Use short sentences for instructions and build in questions which make pupils think about the instructions mean?

Take the instruction

"add the black copper oxide to acid, stirring constantly, until the black powder ceases to disappear".

In a trial, the second phase of this long sentence was given little attention by many pupils (8 out of 18 groups of middleband 4th form pupils didn't read the second part of the statement). Consequently, when a little was added and the solution went blue, they stopped adding the copper oxide thinking they had completed the expected actions (as the aim of the activity was neutralization then clearly they had not). When the instructions were modified to convey the expected actions in two shorter sentences, and when a question drawing attention to the significance of the expected actions was built into the instructions, i.e. "Add black copper oxide to the acid, stirring constantly. Have you added enough? Keep adding the black powder until some doesn't dissolve." a second group of middleband 4th form pupils carried out the activity as expected.

Teaching strategy three: Where instructions involve quantities of materials be precise and avoid confusing statements.

Quantities tend to confuse students. Phrases like:

"take a little ..."
"put a few ..."
"add some ..."

are widely interpreted by pupils and only give them a feeling of insecurity. I have found it much better to specify exact quantities.

e.g. "add 3 pieces ..."
"put 4 ml ..."
"... to a depth of 2 cm."

I have also found that giving pupils everyday equivalents hinders rather than helps pupils in terms of sorting out required quantities of materials. Instructions such as

"take about 2g - that is, a level spoonful", should be avoided.

Similarly, short-cuts aimed at an alternate way, for example, giving a height equivalent for a volume measure with the intention of overcoming skill deficiencies also can create confusion. So avoid this kind of instruction,

> "Put 3 mls of water in your test-tube - that is to a height of 2 cm."

Note: My view is that it is important at the Form 1-4 level to provide the opportunity for pupils to become familiar with measuring quantities and to acquire basic measuring skills. Sure it takes time, but once your class has these skills then the temptation to give out instructions which incorporate difficulties of the type outlined above is much reduced.

Teaching strategy four: Where an activity has a particular purpose then make that purpose explicit and obvious to your pupils.

Where instructions do not clearly establish the teacher's aim for an activity then pupils establish their own aims. These alternative aims rarely provide pupils with the perspective required to achieve the experience intended by the teacher. The following example is based on a trial I carried out with a middle band 4th Form class. The instructions given were:

> "Working in pairs, one pupil kneels so that his eyes are just below the level of the desk top and closes both eyes. The other stands a pin upright on a sheet of cardboard on the desk top so that the kneeling pupil will be able to see the top half of the pin, but not the cardboard. The kneeler now opens one eye and without hesitation brings down the tip of a ball-point pen as near to the pin as possible. Measure the distance from pen mark to pin and find the average error for the class. Repeat the test with both eyes open."

ALL pupils in the trial have been able to read and understand every word of these instructions but many established an unexpected aim. My aim as the teacher was to show that distance judgement is easier with two eyes than one (binocular vision).

However:

(a) Some pupils thought that the experiment was to do with REACTION times. "Bring the pen down WITHOUT HESITATION" to some meant as fast as possible.

(b) Others thought that it was about your eye needing time to focus once it had closed (accommodation).

(c) Some thought it had to do with MUSCLE CO-ORDINATION and were unwilling to mark the paper until they had managed to hit the pin with their pen.

(d) Some noticed that with their left eye open they marked the left side of the pin, but others with their left eye open marked the right side of the pin (and vice versa), so thought the experiment was about CROSSEYEDNESS.

(e) The experiment doesn't tell them where their hands should be at the start. Many students when making sure that they could see the top half of the pin positioned their hands near to the pin in readiness (obviously negating the intended experience).

(f) A further fault with these instructions is that the pin is kept in the same place for two consecutive trials, so if the kneeler sees how far out his first aim was he will subconsciously (or consciously) correct for this on the second run.

These experimental instructions obviously need much modification in order to direct pupils to the intended experience.

Teaching strategy five: Show that mathematical skills and concepts apply to science activities.

Many science activities incorporate mathematical concepts and skills that pupils don't seem to have or at least don't see as applicable to situations outside the maths classroom. I find lower ability pupils for whom even the basic +, -, x, - operational skills are stumbling blocks in my science lessons. I now teach any mathematical operations which is a requirement of a science activity. Taking decimals as an example, pupils in a third form class faced with handling decimals in a science activity involving weighing recorded their measurements as 27.6 1/4g, 3.5 1/2g (mixing fractions with decimals) and 49g instead of 40.9g (not understanding the significance of decimal place value).

I use accurate weighing activities with the triple beam balance to establish the level of appreciation of decimals I require. Pupils enjoy this kind of activity and I kill two birds with one stone, they also become familiar and skilled with using the balance. In the 4th Form I use collecting liquids via a burette dispenser as a reinforce-

ment activity. Again achieving a second objective - introducing a new piece of science equipment.

Note: All of these strategies are really examples of what I see as a major requirement in teaching Junior Science; the teaching of SKILLS. In my experience pupils who have not mastered manipulative skills early enough, find later experiments frustrating. The result is that they see them as merely steps in a teacher's RECIPE, with little thought given to the activity as a whole. They will go through the motions because they have to.

e.g. Observer in classroom of 30 children working in pairs:

Observer: "What are you doing at the moment?"
Pl: "Um ... that one there (points to step 3 in book) No. 3."
Observer: "What is that?"
Pl: (Looks at partner who offers no comment, then picks up book)
Observer: "Can you tell me without reading it?"
Pl: "I've forgotten."
Observer: "What is the whole experiment about?"
Pl: (No response - grins)

(Later, same pair of boys are heating a yellow solid)

Observer: "What are you doing now?"
Pl: "Heating this."
Observer: "I see, what for?"
Pl: "Well ... (races off to desk on other side of room bringing back book) we are doing No. 5."
Observer: "What did you do before you started heating it?"
Pl: "These ones here (points to Nos 3 and 4 of instructions)."
Observer: "Can you tell me what you have found out?"
Pl: "We got this yellow stuff."
Observer: "Can you tell me the purpose of this activity?"
Pl: "No ... not really."

I regularly use Practical Tests on individuals - pupils know that they will need to exhibit skill competence and appreciation to me and this alters their behaviour when working in group situations. I also try to individualise activities wherever possible.

Part of a science teacher's task is to teach students to follow a set of instructions.

Many students have difficulty with activities that involve several steps. They become "muddled" in their thinking and performance. One common reason is that they have not absorbed the main aim of the activity, but there is also the other difficulty of just not taking sufficient time and care to avoid omitting procedural steps and these are habits that can be taught. In Form 1-4 we must give activities that teach skills in a straightforward way and which boost the confidence of the students in their own abilities.

Far too many early science activities are linked to difficult concepts and become too demanding as a result. We must try and keep activities simple!

Editor's comment

In this report the teacher's thinking argues for more effort being made to ensure that pupils do understand the aim of the whole activity and have a sound overview of the science involved. This will not always be achieved and, even if it is, this does not invariably mean that all problems will be solved. There will always be things that need to be done in carrying out the activities, where it is not possible to go into all the ramifications of why a particular aspect of an activity should be carried out in a particular way. Each of the strategies outlined attempt to cope with the problems arising in the course of the activity.

REPORT FOUR : SEEING THE SIGNIFICANCE

Problem

* Pupils have difficulty relating what they did and saw happening to their thinking (section 3a in Table)

Teacher thinking

I consider it important that my pupils relate what they do and see happening in science activities to the views they have established to

explain their world; are aware that others (peers and scientists) may hold different views; and consider which view is the more useful. I therefore try to create situations which force pupils to confront the following questions.

1. What do these findings mean to me?

2. What do my findings and ideas mean to other members of my group?

3. How do our group's findings and ideas stand alongside those of other groups?

Note: I use this approach with all my classes. The strategy works equally well in any classroom setting, and ability grouping.

Teaching Strategy

1. Each pupil records their results and then considers the experience against their own ideas.

2. Pupils put their ideas relating to the experience to members of their group. Discussion generates the group view.

3. The group view is presented to the class by a member of each group with support from any other member of the group.

4. The teacher contrasts group views and directs discussion, raising issues where necessary until a consensus position is reached or further activities have been decided upon.

Note: The group and class aspects of this take up the last 10 minutes of the lesson and can often be an introduction to the next lesson.

Impact of the strategy

I find that using this strategy the discussion which develops is in the language of the pupils and I can use this to work towards presenting

the consensus science view or to direct pupils to further activities which can challenge views that are intuitive rather than scientific.

Pupil: "Its a better way. It shows to yourself that you can understand the work that you're doing".

Editor's comment

The need for pupils to be able to argue the implications of their findings is important and an essential part of good science. It forces pupils to consider the aim of the activity prior to their investigation and to think about the implications of the way they undertake the activity.

REPORT FIVE : USING ASSESSMENT TO INFLUENCE INVOLVEMENT

Problems

* Pupils do things which they think appropriate to reach the end of the activity (Section 2a in Table 1)

* Pupils focus on, and observe, unexpected aspects of the activity. The are preoccupied with 'what is supposed to happen' (Section 2b in Table 1).

* Pupils see the activity as 'getting the right answer' or guessing what the teacher wanted from the activity (Section 2c in Table 1).

* Pupils have difficulty relating what they did and saw happening to their thinking (Section 3a in Table 1).

Teacher thinking

In my view pupils respond better if they know what they are aiming for and what they are being assessed on. Where pupils are assessed solely

on recall tests and examinations of content then pupil involvement in an activity, especially in investigations and experiments, is likely to have for the pupil 'fun' or 'interest' value rather than significance as an opportunity to 'challenge a view' or 'test an idea'. This is because aspects of the activity other than the teacher's conclusion play little part in assessment and are quickly labelled by pupils as unimportant.

Teaching strategy

Develop and use a range of skill assessment procedures with all activities. While the range of skills assessed and form of assessment used, can and should vary with activities of different types, I have developed a checklist which covers the following skills:

(a) Social Skills, e.g.
- Does he/she work with others to check and set up gear
- Can he/she work with one other person
- Can he/she work with a variety of people in a class

(b) Manipulative Skills, e.g.
- Can he/she assemble equipment, prepare a slide
- Read an instrument
- Operate a piece of equipment

(c) Workshop Skills, e.g.
- Does he/she get out gear and put it away
- Clean up their work area
- Can he/she follow guidelines on dangerous experiments

(d) Interpretative Skills, e.g.
- From the results can he/she write a meaningful conclusion
- Can he/she draw and extrapolate graphs

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1. This is not to say that science activities should not be enjoyable, but rather to say that where the role of an activity is that of challenging a view or testing an idea then somehow the real purpose must be achieved.

(e) Cognitive Skills, e.g.

- Can he/she move on from that experiment and devise or relate it to a new experiment
- Can he/she form a hypothesis and abstract ideas from the obtained data.

I assess the skills areas outlined above during activities by making materials and equipment readily available and set up in such a way that at the end of the period there is a simple way of checking gear. I use shadow boards and gear monitors and find them essential.

During the first two periods of the term I draw up a roster for the class so that each period a person is responsible for equipment checks, books checks etc. This roster is displayed on the wall so that their responsibilities are clearly seen. Also a copy of the assessment sheet is given to each student so that they can ask questions and are in complete understanding over what the assessment report is about.

A. Social Skills

During the course of a term each pupil will have some responsibility to the class as a whole and how they carry out this task is easily assessed. Normally every pupil will sit with a friend in the first instant. As the term progresses I assess the interaction of these two by the way they set up experiments and from the results of mastery tests. If the programme is self-paced they will be required to form new partnerships as the experiment and course dictates. These new interactions also are easily observed.

B. Manipulative Skills

Often when two or more pupils are required to do an experiment, one pupil will dominate and often that person has good manipulative skills. However, I frequently find in the background a person who understands the experimental results better. I try to design my programme so that all pupils have a chance to show their skills while at the same time they have maximum opportunity to develop further those skills which are not their strengths. For example, pupils should have

time to demonstrate to the teacher their skills in reading a balance, setting up a circuit, reading a meniscus, making a slide, focussing a microscope etc. and their skill level assessed.

C. Workshop Skills

The effect of safety in our lives and habits is extremely important, and laboratories are good places to learn these skills. Particularly in relationship to electricity, chemicals and general hygiene. At least one safety officer should be present amongst the social responsibilities of the class. Pupils should be encouraged to put gear away, report breakages and clean up spillages. When there is an element of danger, safety precautions should be encouraged. Skills like putting glass through rubber and transferring liquids have application to everyday life. Again I assess these skills on a one to one basis.

D. Interpretative Skills

I try to organize my programme so that I have a chance to assess each pupil on a one to one basis every two periods. My objective at this time is to see what a pupil is placing on any findings that are achieved. I find this type of assessment is best done by mastery testing but even relatively informal discussion with pupils can be formalized to produce a record of skill development.

E. Cognitive Skills

I use a mastery testing technique and one to one discussion.

Impact on pupils

My view is that since adopting a strategy of assessing the range of skills outlined above pupil involvement in activities has changed dramatically. There is evidence of a keener appreciation of instructions and findings. Pupils accept responsibility to carrying out and seek meaning in the activities set. Activities are no longer just enjoyable things to do but also intellectually challenging.

Note: In formalising skill assessment as above it is important to build up profile of each pupil. This is chiefly for each pupils information. However, such profiles can readily be incorporated into a more formal report (see below).

SCIENCE REPORT NAME _____ FORM _____

A. SOCIAL SKILLS

Responsibility to class
Responsibility to group
Ability to mix with others

B. MANIPULATIVE SKILLS

Ability to set up gear
Ability to read and adjust measurements
Ability to follow written practical instruction

C. WORKSHOP SKILLS

Ability to put gear away
Ability to tidy up after experiments
Ability to carry out safety procedures

D. INTERPRETATIVE SKILLS

Ability to set out and couple results
Ability to set out and draw graphs

E. COGNITIVE SKILLS

Ability to formulate a conclusion
Ability to interpret results and make predictions
Ability to formulate ideas

Editor's comment

In spite of a teacher's best intentions to run an activity based science programme, whenever specific content objectives dominate a lesson (and any subsequent assessment), the readiness of pupils to carry out an activity in a scientific manner and the keeness of pupils to approach an activity as a scientific enterprise is threatened. Giving emphasis to skill expectations and assessing pupil skill performance can only enhance the learning opportunities provided by science activities. Firstly, by making pupils more familiar with the skills of science, science activities come under the control of pupils and gain a meaning beyond that of 'something we are trying to do'. And secondly as skills develop, the attitudes and habits of science acquire significance for pupils, again elevating their level of involvement in an activity. The ideas and strategies suggested above offer teachers who are concerned about varying or broadening the range of abilities and interests that are developed by their pupils in investigative science activities, a real chance to improve things.

REPORT SIX : KEEPING A CHECK ON THINGS

Problems

All sections in Table 1.

Teachers thinking

Like all teachers I try to anticipate problems my pupils will have with the activities I use in my lessons. Consequently, I saw in the descriptions of problems set out in Table I, planning requirements which need to be met if an activity is to provide pupils with the experience I wish them to have. My deliberations eventually resulted in three checklists of questions which I use to:-

a. plan activities with close reference to the specific problems outlined in Table 1.

b. gain feedback on the activities on which I base my teaching through self or colleague evaluation

c. gain feedback on the activities from the perspective of the learner through pupil evaluation

Note: The checklists if treated formally take time to complete. However as a way of coming to grips with the problems outlined in Table 1, I find them invaluable.

Teaching strategy one

Using 'A checklist for planning science activities'.

I use this formally when planning activities which I see as providing crucial learning experiences, and informally to scan activities (in texts) that I am considering incorporating into my programme. I find that the checklist quickly exposes any deficiencies in the information available to pupils and makes me think more carefully about the views and skills that pupils need to have if they are to carry out the activity as expected.

Teaching strategy two

Using 'A checklist to evaluate a science activity'.

In the past any evaluation by me of an activity has almost always been either informal or indirect in the sense that I have tested pupils on content objectives only. Such practice tells me when pupils have had difficulty, but does not tell me where the difficulty lies. By using the self-evaluation checklist, I find that I identify specific aspects in the activity which need my attention. More recently I have worked with a fellow teacher using this checklist. We each visited each others classroom during a science activity and used the checklist to describe what we saw, overheard, and were told by pupils. It was a bit strange (although pupils didn't seem to find this) having a colleague acting in this way, but we really feel that both of us gained a lot from the experience. We intend to do more of it in the future.

Teaching strategy three

Using 'A checklist for pupil evaluation of science activity'.

I have also produced a list of questions for pupils that pertain to any activity they are required to get involved with. I've used it in two ways. Firstly, by giving it to one or two selected pupils - pupils who I feel have interacted with the activity in the way I expected, or pupils who I sense have had difficulty and I can't see why - in a class, and secondly, by giving it to all members of a class. My experience is that pupils respond to questions objectively and the information I gain has suggested aspects of an activity that need development.

A CHECKLIST FOR PLANNING SCIENCE ACTIVITIES

1. GENERAL

Class level 3 4 5 6 7 Ability Low Mid High Mixed

No in class: Work: individually in pairs ____ groups of ____

2. BACKGROUND THINKING

2.1 What in particular do I want to achieve? (Knowledge, manipulative skill, experimental design, attitude)

2.2 What is the best kind of activity to achieve this? (Experimentation, demonstration, exploration, problem solving, project)

2.3 In what way will this activity achieve its purpose?

2.4 Are the pupils ready for this activity?
(a) Do they have the background ideas that I expect them to have?

(b) Do they have the required skills for the activity (Manipulation, observation, classification, graph or date interpretation, (see 3.6)

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3. SETTING UP AND CARRYING OUT THE ACTIVITY

3.1 How will I convey my purpose for the activity to the pupils?

3.2 What instructions will I need to give the pupils so that the activity will be carried out as I intend?

3.3 How will I present the instructions (b.b., chart, list of tasks, diagram, flow charts, etc.)

3.4 What level of language will I use?

3.5 How can I highlight critical design features of the activity so that the main points of the activity will not be missed?

3.6 What opportunities need to be provided to learn or review necessary skills?

3.7 What equipment is needed?

3.8 How will the equipment be made available to the pupils?

3.9 How much time should the activity take?

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4. HANDLING THE OUTCOMES

4.1 What directions do I need to give pupils for recording what they are doing, what they observe and what they think it all means?

4.2 What will I do if there is a mismatch between my intended results and the pupils' results and thinking?

OR 4.2 (a) How can other unexpected results and thinking be directed to those of the activity's purpose?

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5. USING THE OUTCOMES

5.1 Where will I go from here?

5.2 What alternative activities could I use to further challenge pupils' thinking if necessary?

A CHECKLIST TO EVALUATE A SCIENCE ACTIVITY

1. GENERAL

Evaluation by SELF COLLEAGUE

2. BACKGROUND THINKING

2.1 What purpose for the activity did pupils adopt? (The teacher's or another?)

2.2 How was this shown? (observation, questioning individuals etc.)

2.3 Did the kind of activity suit the purpose?

2.4 Were the pupils ready for the activity?
(a) Did they have appropriate background ideas?
(b) The skills required to carry out the activity as expected?

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3. CARRYING OUT THE ACTIVITY

3.1 Did pupils have any trouble working out what to do? If so, what caused the trouble (language, comprehension, unfamiliar equipment, etc.?)

3.2 Did pupils appear to really understand what they were doing? (Did pupils understand the design features of the activity?)

3.3 Were there any unexpected problems with using the equipment or materials?

3.4 Did pupils have the skills required to carry out the activity as expected?

3.5 Did the students have enough time to do the activity?

4. HANDLING THE OUTCOMES

4.1 Did the pupils get their own results? What did they do with them?

4.2 Were they the results "expected" by the teacher?

4.3 How were the results and thinking of the pupils related to the purpose of the activity - did they draw their own conclusions?

4.4 Did pupil conclusions match those expected by the teacher? If not was the teacher aware of the mismatch and were any such mismatches effectively considered by the class?

A CHECKLIST FOR PUPIL EVALUATION OF A SCIENCE ACTIVITY

Please answer the following questions in terms of how you see the activity.

1. What were you trying to find out or show?

2. Were the instructions easy to follow?

3. What words did you find hard?

4. Did you know exactly what to do?

5. Was anything hard to do or understand?

6. If you asked for help, who did you ask?

7. Why that person?

8. When you did each part of the activity, did you really know what you were doing?

9. If you talked to other pupils about the activity, which did you talk about?

10. What were the results you got from the activity? What did your results mean to you?

11. When you got a result, did you think it was what the teacher expected you to find out?

12. What did you do with your results?

13. What have the results to do with what you were trying to find out, show, or prove?

14. Did you really understand what you were doing during the activity?

Editor's comment

One of the needs in teaching an activity based progamme is to be sensitive to critical issues and pupil needs and inadequacies. The importance of the checklists is primarily in sensitizing teachers to the critical issues that need to be thought about in planning; the critical issues on which feedback should be obtained; and the critical issues in terms of what the learner should also think about and report on. A complete checklist need not be used with respect to all aspects of an activity at any one time. For example, it may be more manageable to focus on one or two features of an activity at any one time (possibly by drawing on parts of all three checklists) e.g.

How can I highlight critical design feature of the activity so that the main points of the activity will not be missed? (teacher)

Did pupils really understand the design features of the activity? (colleague)

Did you really understand what you were doing during the activity? (pupil)

These three perspectives would give a teacher considerable insights, into how his/her view of an activity linked with the learners view.

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